# Efficient Quantification of Uncertainties in Complex Computer Code Results, Phase I

Completed Technology Project (2010 - 2011)

## Project Introduction

This proposal addresses methods for efficient quantification of margins and uncertainties (QMU) for models that couple multiple, large-scale commercial or proprietary simulation codes, effective methods for treating epistemic uncertainty in large scale simulations, scalability to models with hundreds or thousands of uncertain parameters, and competition with traditional Monte Carlo Based methods. The Reduced-Order Clustering Uncertainty Quantification (ROCUQ) methodology described in this proposal has been under development over the past several years at the University of Illinois, and is being commercialized by IllinoisRocstar LLC. ROCUQ uses a combination of common stratified Monte Carlo techniques, coupled with well-chosen reduced order models, statistical clustering, and a few (less than tens) high-fidelity simulation runs to provide estimates of the uncertainty distributions for the System Response Quantities (SRQs) of interest to the modelers. The goal of the ROCUQ methodology is to minimize the number of high-fidelity, computationally-intensive simulation runs that are needed in order to provide estimates of output uncertainties of interest, especially when it is not possible to run the high-fidelity model more than a few (e.g., 5 to 10) times. ROCUQ has been, or is currently being applied to solid propellant rocket internal ballistics uncertainties, coupled fluid-structure interaction modeling of stresses in an Air Force Training Fighter wing, and structural dynamics/vibration of a specially-designed experimental apparatus for studying simulation validation under uncertainty.

## Primary U.S. Work Locations and Key Partners
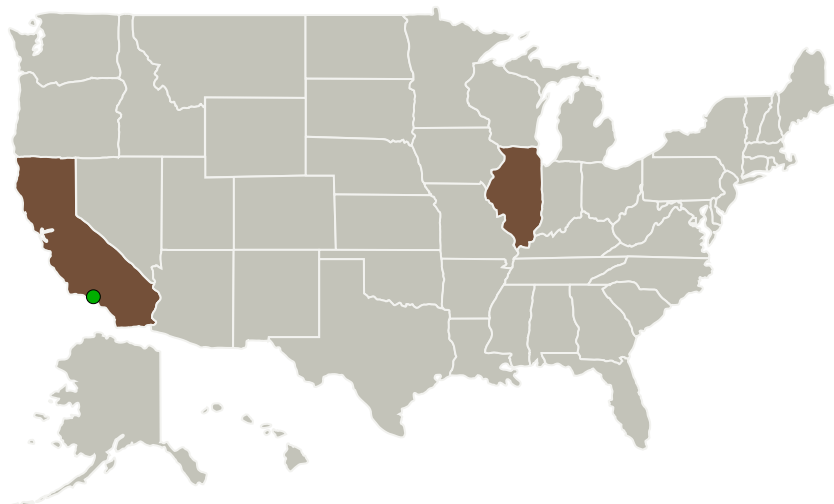




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## Table of Contents

For more information and an accessible alternative, please visit:
https://techport.nasa.gov/view/10331

| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| IllinoisRocstar, LLC | Lead Organization | Industry | Champaign, Illinois |
| 🟢 Jet Propulsion Laboratory(JPL) | Supporting Organization | NASA Center | Pasadena, California |
| University of Illinois at Urbana-Champaign | Supporting Organization | Academia | Urbana, Illinois |

| Primary U.S. Work Locations | |
|---|---|
| California | Illinois |

## Project Transitions

▶ **January 2010:** Project Start

✔ **January 2011:** Closed out

    **Closeout Documentation:**
- Final Summary Chart*(https://techport.nasa.gov/file/140142)*

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

IllinoisRocstar, LLC

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management
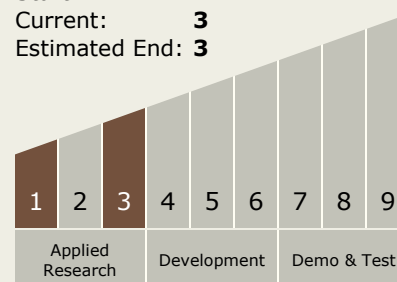
**Program Director:**

Jason L Kessler

**Program Manager:**

Carlos Torrez

**Principal Investigator:**

William A Dick

## Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| Applied Research | | | Development | | | Demo & Test | | |

## Technology Areas

**Primary:**

- TX09 Entry, Descent, and Landing
  └ TX09.4 Vehicle Systems
    └ TX09.4.5 Modeling and Simulation for EDL

## Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System